

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 7,268,503 B2
APPLICATION NO. : 10/508992
DATED : September 11, 2007
INVENTOR(S) : Yamasaki et al.

Page 1 of 5

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Delete the title page and substitute therefore the attached title page consisting of corrected number of claims in printed patent.

Column 8, line 20 - Column 10, line 41, delete claims 1-21 and substitute therefore with the following claims 1-16:

1. A vibration linear actuating device comprising a vibrating linear actuator and a driver for driving the actuator; the vibrating linear actuator including:
 - (a) a mover having a permanent magnet magnetized in a radial direction
 - (b) a stator having a coil and facing the permanent magnet; and
 - (c) an elastic body for coupling the stator to the mover and energizing the mover toward a center of the stator, the driver including:
 - (d) a driving section having a switching element for powering the coil;
 - (e) and output controller for controlling the switching element; and
 - (f) a zero-cross detector for detecting a zero-cross point of back electromotive force (BEMF) generated in the coil and outputting a zero-cross signal;
wherein the driver transmits the zero-cross signal to the output controller and powers the coil in one direction for vibrating the mover in corporation with the elastic body,
characterized by
 - (g) a zero-cross monitor interposed between the zero-cross detector and the output controller, the zero-cross monitor monitoring the zero-cross signal and prohibiting acceptance of a next zero-cross signal for a given time after input of the zero-cross signal.
2. The vibration linear actuating device of claim 1, wherein the driver transmits a re-starter signal to the output controller when the zero-cross signal is halted for a given time.
3. The vibration linear actuating device of claim 1, wherein the zero-cross detector is coupled to the coil via a BEMF amplifier and a level-shift section.

4. The vibration linear actuating device of claim 1, wherein the driver further includes a timing adjuster disposed between the zero-cross detector and the output controller.

5. The vibration linear actuating device of claim 4, wherein the timing adjuster includes a phase locked loop.

6. The vibration linear actuating device of claim 1, wherein the output controller includes a pulse width modulator.

7. A method of driving a vibrating linear actuator, the actuator comprising:
a mover having a permanent magnet magnetized in a radial direction;
a stator having a coil and facing the permanent magnet; and
an elastic body for coupling the stator to the mover and energizing the mover toward a center of the stator, the method comprising the steps of:

(a) determining a zero-cross point of back electromotive force generated in the coil;
(b) determining a period for powering the coil in every cycle;
(c) determining a period for powering the coil at starting time;
(d) counting step (b) based on the determined result of step (a); characterized by the additional step of
(e) starting to count depending on the judging result at step (a), wherein the judging result at step (a) is kept invalidated until counting up at step (e).

8. The method of driving a vibrating linear actuator of claim 7 further comprising step (f) for counting for itself based on the determined result of step (a), wherein step (c) starts counting when step (f) counts up.

9. The method of driving a vibrating linear actuator of claim 8, wherein step (f) is reset depending on a next determined result.

10. A portable information apparatus comprising:
(a) a board;
(b) a vibrating linear actuator mounted to the board; the actuator including:
(b-1) a mover having a permanent magnet magnetized in a radial direction;

(b-2) a stator having a coil and facing the permanent magnet; and
(b-3) an elastic body for coupling the stator to the mover and energizing the mover toward a center of the stator;
(c) a driver mounted to the board, the driver including:
(c-1) a driving section having a switching element for powering the coil;
(c-2) an output controller for controlling the switching element; and
(c-3) a zero-cross detector for detecting a zero-cross point of back electromotive force (BEMF) generated in the coil and outputting a zero-cross signal;

wherein the driver transmits the zero-cross signal to the output controller and powers the coil in one direction for vibrating the mover in corporation with the elastic body,

characterized by

(c-4) a zero-cross monitor interposed between the zero-cross detector and the output controller,

the zero-cross monitor monitoring the zero-cross signal and prohibiting acceptance of a next zero-cross signal for a given time after input of the zero-cross signal.

11. The portable information apparatus of claim 10, wherein the vibrating linear actuator generates vibrations with a maximum amplitude in a vertical direction to the board.

12. The portable information apparatus of claim 10, wherein the driver transmits a re-starter signal to the output controller when the zero-cross signal is halted for a given time.

13. The portable information apparatus of claim 10, wherein the zero-cross detector is coupled to the coil via a BEMF amplifier and a level-shift section.

14. The portable information apparatus of claim 10, wherein the driver further includes a timing adjuster disposed between the zero-cross detector and the output controller.

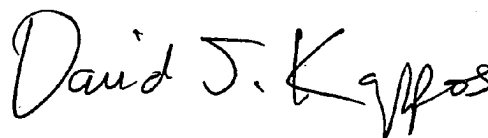
15. The portable information apparatus of claim 14, wherein the timing adjuster includes a phase locked loop.

16. The portable information apparatus of claim 10, wherein the output controller includes a pulse width modulator.

This certificate supersedes the Certificate of Correction issued March 23, 2010.

Signed and Sealed this

Twentieth Day of April, 2010

A handwritten signature in black ink that reads "David J. Kappos". The signature is written in a cursive, flowing style with a large initial 'D' and a stylized 'K'.

David J. Kappos
Director of the United States Patent and Trademark Office

(12) **United States Patent**
Yamasaki et al.

(10) **Patent No.:** **US 7,268,503 B2**
(45) **Date of Patent:** **Sep. 11, 2007**

(54) **VIBRATION LINEAR ACTUATING DEVICE,
METHOD OF DRIVING THE SAME DEVICE,
AND PORTABLE INFORMATION
APPARATUS USING THE SAME DEVICE**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 451 days.

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(52) U.S. Cl. **318/114; 318/459; 318/500; 318/254; 388/928.1**

(58) **Field of Classification Search** **318/254, 318/138, 439, 114, 115, 459, 500; 388/928.1**
See application file for complete search history.

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(57) **ABSTRACT**

A vibration linear actuating device includes a vibrating linear actuator and a driver (52) for driving actuator. Actuator includes mover having permanent magnet magnetized in a radial direction, stator having coil (2) and facing the permanent magnet, and elastic body for coupling stator to mover. The driver includes driving section having switching element (Q5) for powering coil (2), output controller (27) for controlling switching element (Q5), zero-cross detector (25) for detecting a zero-cross point of back electromotive force generated in coil (2) and having an output to be fed back to the output controller (27). In this structure, the driver powers coil (2) in one way to keep mover vibrating in corporation with elastic body.

16 Claims, 12 Drawing Sheets

